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MARCH, 1926

Featuring

Bartlett's Ferry
Hydroelectric
Development

The Engineer
and Public Health



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THE BARTLETT'S FERRY HYDROELECTRIC DEVELOPMENT

BY H. A. HAGEMAN * AND T. B. PARKER,† MEMBERS, BOSTON SOCIETY OF
CIVIL ENGINEERS

(Presented February 17, 1926)

THE power requirements of the southeastern section of this country are supplied largely from hydroelectric developments.

During recent years the demand for electric power in that locality has increased rapidly, with the result that the power companies have frequently found it necessary to provide additional capacity.

Among those companies requiring more capacity to keep pace with the load growth of their system is the Columbus Electric and Power Company. This company serves a territory in Alabama and Georgia southwest from Atlanta, the system centering in Columbus, Georgia.

The Columbus Electric and Power Company owns and operates several hydroelectric stations on the Chattahoochee River, and has recently put into service its new water power station on this river at Bartlett's Ferry. The new station is 6 miles upstream from its Goat Rock plant and 20 miles north of Columbus.

The Bartlett's Ferry development was designed and constructed by Stone & Webster, Inc. Mr. Charles T. Main was Consulting Engineer. The purpose of this paper is to describe some of its engineering and construction features.

The Chattahoochee River rises in northeast Georgia, flows southerly, and with the Flint River forms the Apalachicola River, the latter emptying into the Gulf of Mexico. The length of the Chattahoochee from its source to the junction with the Flint River is approximately 350 miles, and from this point to the Gulf of Mexico the distance is about 75 miles. In general, the river gradient is small except in the stretch between West Point and Columbus, which contains many rapids,

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the river falling about 375 ft. in 40 miles. Bartlett's Ferry is located midway between these places.

In planning the development the principal consideration was given to the following:

1. An analysis of the stream flow records above the site.
2. The type, location and design of structures required.
3. Selection of the hydroelectric machinery and appurtenances.
4. The construction equipment and its arrangement.

These and many other items were studied in designing and constructing the project, but those enumerated list briefly the salient points which were fundamental requirements for an economical development.

An important matter to be thoroughly investigated in planning a new hydroelectric development is the availability and distribution of the stream flow, and the occurrences and amounts of the floods. In this case ample information was available.

The Chattahoochee River at Bartlett's Ferry has a drainage area of approximately 4,200 square miles. The U. S. Geological Survey maintains a gaging station at West Point, 20 miles upstream from the site, and the stream flow has been recorded for the past thirty years. The average run-off of the river at West Point has been about 1.9 cubic feet per second per square mile, and is most unevenly distributed throughout the year. Flows over 40,000 c.f.s. occur several times during an average year, and there has been at least one flood of 165,000 c.f.s. The lower flows are ordinarily well sustained, so that a discharge of at least 2,000 c.f.s. is available 90 per cent of the time, but there are occasional periods of extended drought.

Throughout the latter part of 1925 a severe drought prevailed over the entire south, which was generally helpful to construction operations, but necessitated a curtailment of the output of most of the power systems. During this period the Chattahoochee River at Bartlett's Ferry reached an extreme minimum flow of 225 c.f.s.

HEAD

The amount of head available is limited by the difference in elevation between the Goat Rock pond, normally at Elev. 406, and the tail-water level of a water power plant at Riverview, 10 miles upstream, which is ordinarily above Elev. 521. To make provision for the backwater slopes due to ordinary flows, the normal headwater level at Bartlett's Ferry was fixed at Elev. 520. With allowance for friction losses and ordinary fluctuations in head and tail water levels, this will give an average effective head of about 112 ft.

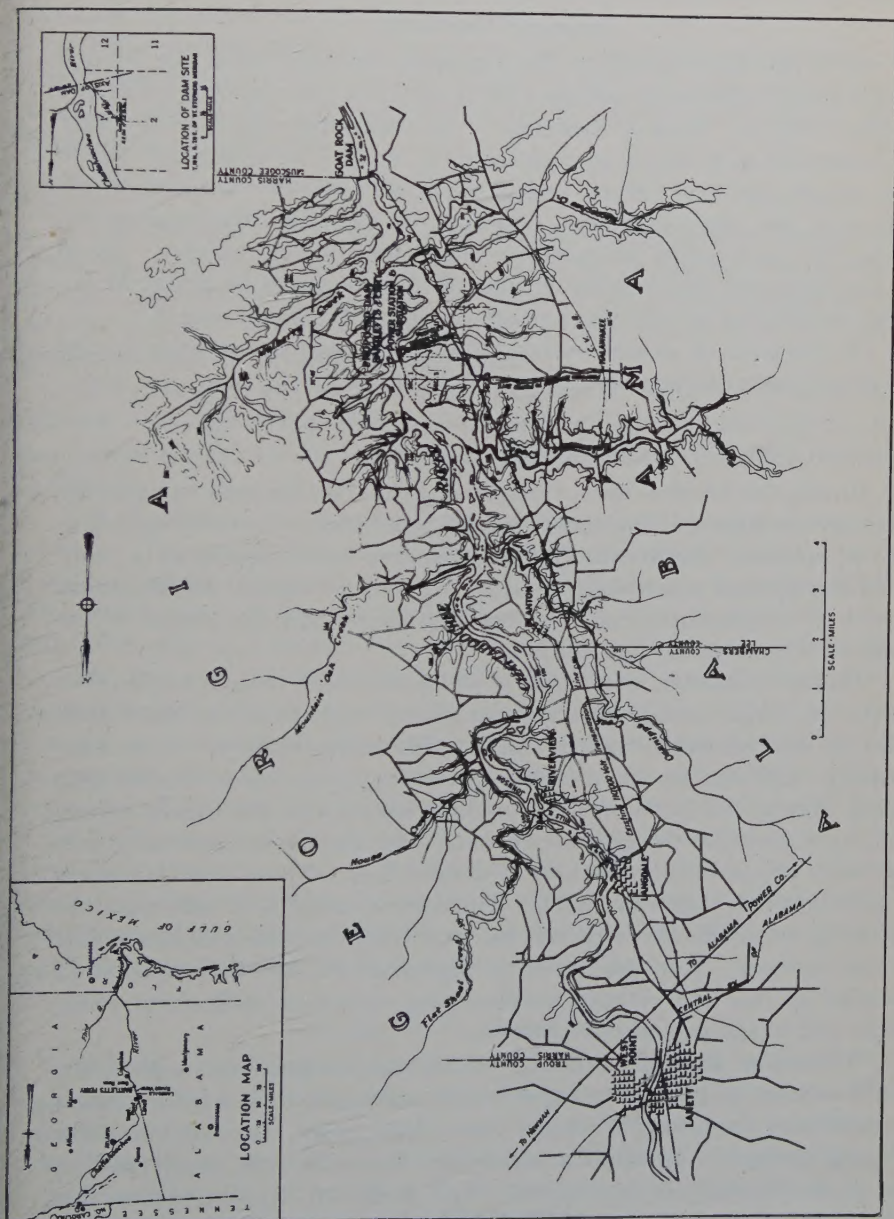


FIG. 1. — GENERAL MAP — BARTLETT'S FERRY HYDROELECTRIC DEVELOPMENT ON CHATTAHOOCHEE RIVER —
 COLUMBUS ELECTRIC AND POWER COMPANY

STORAGE CAPACITY

With the water raised to the proposed operating level, the flooded area is about 5,700 acres and the total capacity of the reservoir is 175,000 acre ft. (Fig. 1. Map of Reservoir.) To determine what can properly be considered as available storage capacity, studies were made of stream flow records and load curves, and of the possibilities of combined operation with the other generating stations on the Columbus system, including its water power plants downstream from Bartlett's Ferry. These studies indicated the economical limit of drawdown to be about 31 ft., which would give an effective storage capacity of 120,000 acre ft.

On the basis of all previous records this storage will provide during the driest season an equalized flow of 1,320 c.f.s.

GENERATING CAPACITY

Having the low flow data, the storage available, the load curve of the company's system and the operating characteristics of its existing hydro-electric stations, the Bartlett's Ferry station was planned as a combined storage and power development, not only to obtain the maximum benefit of its generating capacity, but also to increase the output of the company's existing stations below it.

This development, on account of its location with respect to the other plants, its large storage and comparatively high head, is the logical point to develop peak capacity for the Columbus system. It was accordingly laid out for an ultimate generating capacity of 60,000 kw., which, taking into account the probable character of the future system load, appears to be the greatest capacity that can be economically utilized with the present regulation of stream flow. There will ultimately be four units of 15,000 kw. each. This size of unit fits in well with the operating requirements of the system and with the expected increments of load increase. It is also about as large a unit as can be conveniently installed at this site without encountering structural difficulties which would add to the cost of construction.

While the development as a whole was designed for a predetermined amount of generating capacity, it is recognized that future power requirements may differ from the present estimates. In order to allow for such changes, and also for a possible increase in the regulated flow due to development of upstream storage, a limited amount of provision was made for the addition of a fifth 15,000 kw. unit. This provision for a possible extension to 75,000 kw. involved very little expense, and con-

sisted merely in locating and arranging certain structures so as not actually to prohibit the extension.

The initial installation is limited by the immediate requirements of the power company, and consists of two 15,000 kw. units, with provision for adding the third and fourth units "in the dry" without the construction of cofferdams.

POWER SITE

The Bartlett's Ferry dam site is located at the head of backwater from the Goat Rock plant, completed for the Columbus Electric and Power Company in 1913. Here the valley of the Chattahoochee River is comparatively narrow and conditions for dam construction are more favorable than for several miles upstream.

The river bed at this point was about 500 ft. wide, and at an elevation of 75 ft. above the original water surface the width between banks was about 875 ft.; 125 ft. above the stream the width was approximately 2,000 ft.

In the bed of the river hard rock is exposed all the way across the stream. This rock, although in places folded and badly seamed, can be made to furnish an excellent foundation. Rock of this character underlies both banks but at varying depths. On the west, or Alabama side, the solid rock is overlaid with from 5 to 20 ft. of soft rock and earth, but the bed rock slopes steeply upward and forms a satisfactory abutment. On the east, or Georgia side, the rock also slopes upward but less steeply, and is covered by a mass of soft rock and earth, which is in places more than 80 ft. deep. Next to the river this soft material forms a mound which rises to a height of 100 ft. above the original water surface, but further east the ground falls away to a swale or saddle which is over 30 ft. lower than the top of the mound. At a level of 125 ft. above the original water surface a dam over 1,000 ft. long is required east of the river bed, and throughout this entire distance bed rock is in general more than 20 ft. below the surface of the ground.

PRELIMINARY OPERATIONS

The first step in planning the new development was to secure the necessary information regarding the existing physical features. This required information came under two heads: first, as to foundation conditions at the dam site, and second, as to the amount and extent of reservoir flowage.

Exploration work at the site was carried on by means of a series of test borings, including diamond drill holes, wash borings, and test pits,

so laid out as to cover the ground along the axis of the dam, and the sites for proposed structures on both sides of the river.

A complete topographic survey of the dam site and reservoir area was made, and maps drawn up with a contour interval of 10 ft. These surveys were later extended to include the location of all property lines within and adjacent to the flowage. The area covered was very irregular in shape and in large part thickly wooded, so that extensive surveys were required.

Following the preparation of preliminary estimates based on the above borings and surveys, application was made to the Federal Power Commission for a license to construct and operate a power plant at Bartlett's Ferry. The Federal Power Commission had previously assumed jurisdiction over this site, in view of the effect of the proposed stream flow regulation upon navigation downstream. To accompany this application, a number of special maps and drawings were made, and a detailed description of the proposed works prepared in compliance with the regulations of the Commission.

GENERAL TYPE OF DEVELOPMENT

One of the most important problems to be settled in designing the development was the type of dam to be used. The general requirements were as follows:

1. A normal headwater level at Elev. 520.
2. A spillway capacity safely in excess of the maximum recorded flood.
3. Regulation of reservoir level so as not to affect the tailwater of power plants upstream.

Preliminary studies made in advance of the test borings indicated the most economical arrangement to be a reinforced concrete non-overflow section across the river bed with a gate-controlled spillway on the east bank. It was found, however, when the borings were completed, that this scheme was not as well suited to actual conditions as had been hoped, owing to the necessity for carrying the spillway foundations to solid rock. As previously noted, rock on the east bank was at considerable depths below the surface. (Fig. 2. General Plan of Development.)

Final comparisons showed that a solid gravity type overflow spillway in the river bed, with earth embankments at both ends, could be constructed for nearly the same cost as any kind of hollow or reinforced concrete structure. Since the solid dam has the advantages of greater simplicity and durability, it was the type adopted.

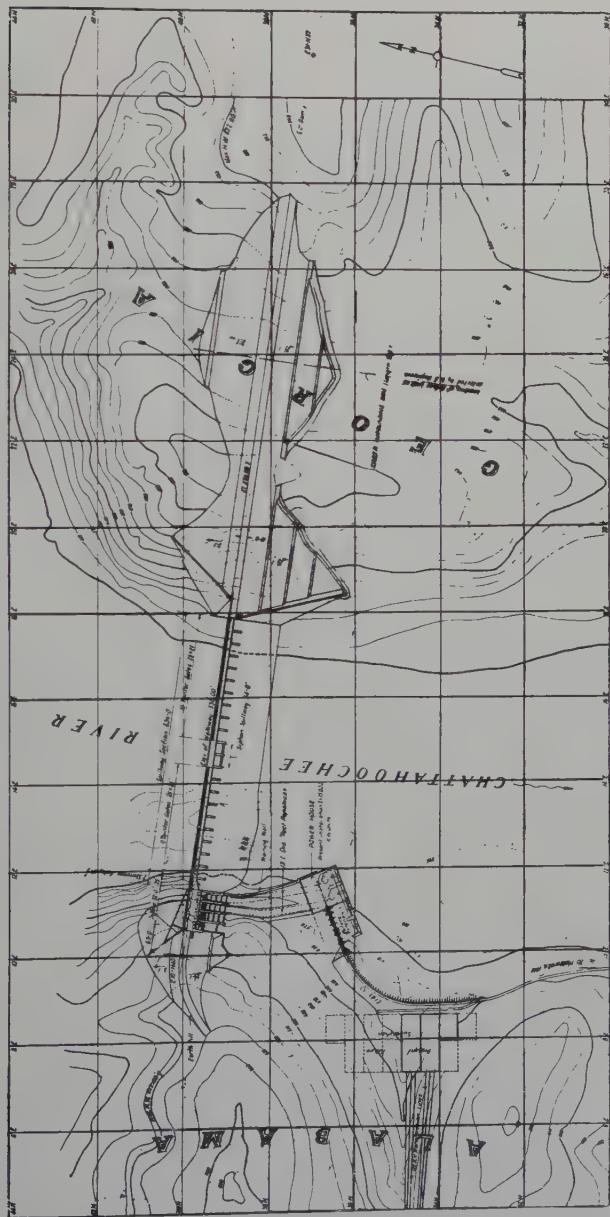


FIG. 2. — GENERAL PLAN OF DEVELOPMENT — BARTLETT'S FERRY PROJECT

Designed and constructed for the Columbus Electric and Power Company of Columbus, Georgia, by Stone & Webster, Inc., Boston, Mass.

With this plan of development it was necessary to utilize practically the entire width of the river bed for spillway purposes, so that the power house could not be located in or directly below the dam. The deepest channel was on the west side of the river, and foundation conditions on the west bank were more favorable for the construction of an intake and power house than on the opposite shore.

As actually completed the dam has a maximum height above bed rock of 145 ft. and a total length of 1,975 ft. over all. Of this distance, 634 ft. is concrete spillway, 92 ft. concrete intake structure, and the remainder earth embankment. The intake is divided into four bays, two of which will be used for the initial installation and two reserved for the future increase in station capacity. From the intake, steel penstocks extend downstream about 300 ft. to the power house. (Fig. 3. Profile of Development.)

Electric power is generated at 12,000 volts, and carried at this voltage from the power house on overhead supports to an outdoor substation a short distance downstream. In the substation the current is stepped up to 110,000 volts and sent out on the transmission system of the Columbus Electric and Power Company.

SPILLWAY

The spillway is constructed on solid rock foundation throughout its length. This rock varies from about Elev. 400 at either shore to Elev. 383 in the deepest channel. Its character differs considerably in different parts of the stream bed. On the east side it has a comparatively smooth hard surface, but in and near the deep channel on the west side a quantity of weathered and broken material had to be removed before a suitable foundation was reached. Some seams were encountered which were opened up and grouted under pressure. The grouting operations were not extensive, however. A good foundation was secured without difficulty and with comparatively little excavation.

It was not found economical to extend the concrete overflow section much beyond the banks of the original stream bed. This definitely limited the length of spillway available and necessitated the use of deep crest gates in order to furnish the required flood capacity without undue variation in headwater level. The permanent crest was therefore placed at Elev. 500, 20 ft. below normal reservoir level.

The design of the concrete section is along conventional lines, except that to provide a sufficiently flat curve for the deep overflow the crest is overhung 8 ft. beyond the upstream face of the dam. In this way the proper face curve is obtained without unduly increasing the

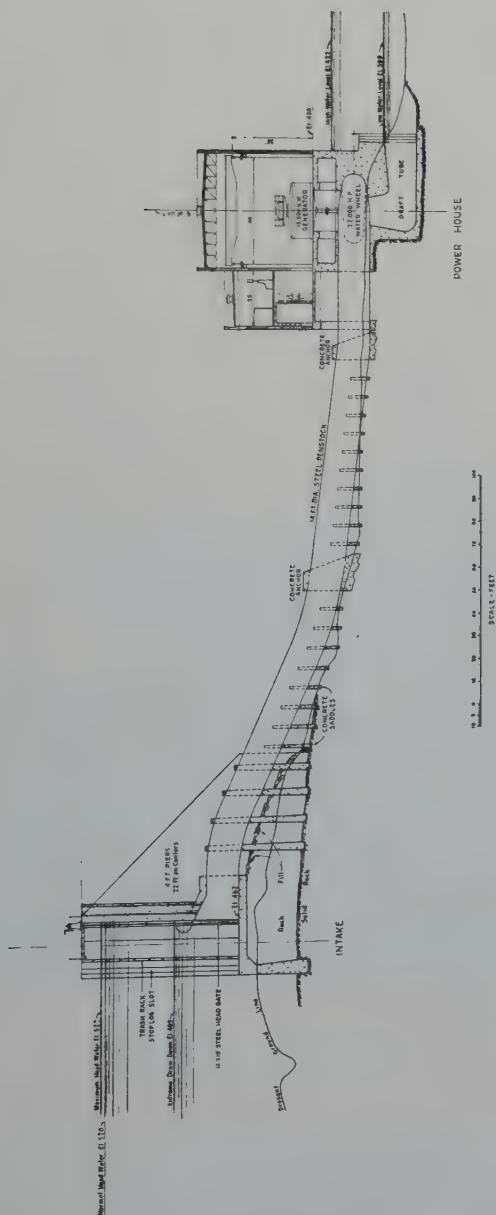


FIG. 3. — PROFILE OF DEVELOPMENT

amount of concrete. (Fig. 4. Cross Section of Spillway.) Upward pressure on the base due to uplift was assumed to vary from two-thirds static head at the heel to zero at a line 15 ft. downstream from the heel. Pressure over the greater part of the base, however, is expected to be relieved by underdrains constructed of open joint tile pipe, and surrounded by loose rock. The section was also analyzed for a number of other conditions, including different degrees of silt pressure.

SPILLWAY EQUIPMENT

The regulating structures on the crest of the dam include nineteen tainter gates, two skimmer gates, and a battery of four siphon spillways. The tainter gates furnish flood capacity, the skimmer gates per-



FIG. 5. — TAITER GATE
Assembled ready for placing

mit manual regulation and disposal of trash, while the siphons are designed to regulate automatically the reservoir level for small increments of stream flow. There are also four sluiceways through the base of the dam. (Fig. 5. Tainter Gate.)

The tainter gates are each 25 ft. long and 21 ft. high and are of structural steel. Each gate weighs about 15 tons and is mounted on cast steel trunnions which bear against steel pins 9 in. in diameter. The bottom seat is made with timber against a steel sill and the side seals by strips of rubber belting sliding along curved steel guide angles. The gate piers are of reinforced concrete 4 ft. thick, and support a heavily reinforced concrete operating platform whose top is at Elev. 530, or 10 ft. above normal pond level. Each gate is raised by means of two iron chains carried up through slots in the deck. When the gate is in an open or partly open position, these chains are supported in cast steel dogs and the loose ends of the chain stored in pockets under the platform.

The tainter gates are raised and lowered by means of two specially built gantry cranes which travel on rails laid along the operating platform. Each crane will be completely housed and is so designed that it can also handle all stop logs and trash racks. For the present, one complete motor-operated crane is being installed, together with one skeleton crane arranged for emergency hand operation.

The skimmer gates are each 11 ft. long and 8 ft. high and are of the sliding drop type. Each gate has an individual motor-driven double screw hoist with stems placed entirely within the gate slots so as to leave an unobstructed opening. When opened, the gates are pushed down behind the upstream face of the dam. They are to be used mainly for regulation and for passing trash, and for that purpose are located at the west end of the spillway next to the intake.

The siphon section consists of four separate units, each siphon having a throat 4' 0" high and 11' 3" long. The crest of one siphon section is at Elev. 520 and the crests of the others at elevations one, two and three inches, respectively, above Elev. 520. The air-vent seals are in each case at the same elevations as their respective crests, so that the different units will prime successively as the water rises, and will break successively as the pond level falls. On account of the large reservoir area and the desirability of securing close regulation, the siphons were designed with a view to having each unit prime and break within as narrow a margin as possible. For this purpose the profile was laid out to give an actual seal at the lower end of each siphon. The upper leg of each siphon was also inclined backwards, so that when the water overflows the upper crest it falls in a thin sheet across this upper leg. This design provides a double seal and gives the desired quick priming action, but on account of the sharp curvature there is necessarily some sacrifice of discharge capacity. At bends where the water will tend to leave

the inside face of the siphon, castings and steel plates have been placed to protect the concrete surface from cavitation.

Owing to the special features of this siphon it was thought advisable to check the calculated performance by actual tests on a model. This was done in the testing flume at the Massachusetts Institute of Technology on a model with dimensions one-fifth of full size. This model primed readily and gave a discharge very close to the estimated figure, which was considered satisfactory as far as the practical aspects of the installation are concerned.

For closing the floodgate openings when necessary to make repairs on the tainter or skimmer gates, steel stop logs have been provided, which are put into place by the gantry cranes. These stop logs are made up in four panels, each 5' 8" deep, and are handled by means of a specially designed lifting beam which is hoisted by the gantry crane. The lifting beam has swinging links which fit cast steel hooks in the upper faces of the stop-log panels. These links can be set either to engage or to release the hooks automatically, thus permitting the handling of stop logs while under water if necessary. Similar stop logs are provided for shutting off any one of the intakes. Since the intake bays are much deeper, eight panels are required each 7' 6" deep. When not in use, all stop-log panels are stored in the upper ends of their slots.

Through the base of the dam are four sluiceways. These sluiceways are each 4 ft. in diameter at their upstream ends, and each is closed by a 4' x 4' Coffin sliding sluice gate, which is operated by a screw stem extending up the face of the dam to a motor-operated hoist on the upper operating platform. The sluiceway openings are lined with steel plate pipe. Midway through the dam these sluiceways taper from 4 ft. to 3 ft. diameter openings, which are closed near their downstream ends by 3 ft. Rensselaer electric motor operated gate valves. These gate valves are located in pits which are reached by way of the inspection gallery through the dam. The double control of these sluiceways provides a means of closure in case of accident to one of the pair of gates. The taper in the sluiceway opening is expected to improve entry conditions and to prevent excessive vibration due to the formation of a vacuum behind the upstream gate.

The purpose of these sluiceways was mainly to provide a means of by-passing water during the time the reservoir was being filled, or whenever the pond is in the future drawn down below the spillway crest. It will also be possible to use them to assist in regulation, or to remove sediment from behind the dam, although it is recognized that any such removal would be purely local in its effect and of doubtful benefit.

An inspection gallery with floor at Elev. 430 runs the entire length of the spillway section. Access to this gallery at the west end is by means of a stairway leading down from the lower intake platform. At the east end of the spillway there is a shaft equipped with removable gratings which can be used if necessary for removing gate-valve parts.

Transverse expansion joints are located about 87 ft. apart throughout the length of the spillway section. These joints were obtained by painting the surfaces at vertical construction joints with hot tar. In the operating bridge these joints occur over every third pier, and are so designed that the piers at the joints are fixed to one adjacent span but free from the other.

EARTH DIKES

There are two earth dikes or embankments, one 990 ft. in length at the east end of the dam, and the other 260 ft. long west of the intake. The east dike contains 215,000 cu. yd. and has a maximum height of 100 ft. The west dike is 40 ft. high and contains 13,000 cu. yd.

The only material available for these embankments was the native red clay, which forms the top soil throughout this district. Underneath this clay, and in some cases mixed with it, are varying amounts of disintegrated sandstone.

In order to test the behavior of this clay when in actual service, a small model dam was built near the site of the same proportions as the full-sized structure. This model was built in a ravine upon a rock bottom. Some percolation occurred along the surface of this rock, and a portion of the downstream toe became saturated and slipped slightly. It was felt, however, that this was due to the presence of the rock bottom, and that such seepage would not take place underneath a dam with an earth foundation and proper underdrainage.

The dikes as built are 16 ft. wide on top, with an upstream slope of 3 to 1 and a downstream slope of $2\frac{1}{2}$ to 1. The upstream slope is riprapped from above high water to the lowest ordinary drawdown. The downstream slope is terraced, drained and planted with grass seed. The downstream third of the dam is also underdrained with a system of open joint tile drains at each 20 ft. level, the underdrains being brought out and connected to the surface drainage.

In building the embankments the material was placed in 6 in. layers, sprinkled, and rolled with a 15-ton power-driven roller. Practically all of the fill placed is solid clay, although such loose material and rock fragments as it was found necessary to handle were also utilized and placed in the downstream third of the dikes. Loose rock fills were

placed against the toes of the earth embankment, both up and down stream.

At the junction of earth dikes and concrete structure, high retaining walls were required to hold back the earth fill. On account of their unusual height these walls presented a very interesting problem. An effort was made either to eliminate or reduce them in size by substituting long earth slopes toward the river, but this was not found practicable. For the wall at the east end of the spillway, which has a maximum height of 110 ft., the type selected is a gravity section, but with both front and rear faces sloped back towards the fill so that the top of the wall considerably overhangs the base. This design represents a large saving over the ordinary gravity type, and at the same time is sufficiently heavy to be in keeping with the massive gravity-type spillway section.

The retaining wall at the west side of the river has a maximum height of 70 ft. As it forms one side of the intake, which is a reinforced concrete structure, it was designed in a similar way with a face slab and buttresses. An unusual feature is the provision for the construction of a fifth penstock underneath part of this wall, as will be described later.

INTAKE

The intake is located on the west bank of the river, on a foundation of solid rock. This intake is a reinforced concrete structure resting upon a block of mass concrete. It is divided into four bays, each having a clear width of 19 ft. at the upstream face of the piers. The intake floor and gate sills are at Elev. 462 and the upper deck at Elev. 530, in prolongation of the operating bridge across the spillway. Each bay is arranged for the installation of head gate, trash racks and stop logs.

The head gates are of structural steel, weighted with concrete, and each closes an opening 15 ft. wide by 20 ft. high. The gates are of the sliding type with bronze seats, and are raised by means of powerful electric motor operated double screw hoists. Each gate stem is 9 in. in diameter. The gates weigh 19 tons apiece and are each ballasted with about 30 tons of removable concrete blocks. The hoists are designed to close the head gates under the full operating head, but to open a gate an 18-in. by-pass must be used to equalize the pressure. (Fig. 6. Head Gate Hoist.) An unusual feature of these gate hoists is a gear shift, by which the power of the hoist can be increased to two and one half times the normal power but with corresponding reduction in speed. This gear shift is for emergency use in case a gate should stick in a partly closed

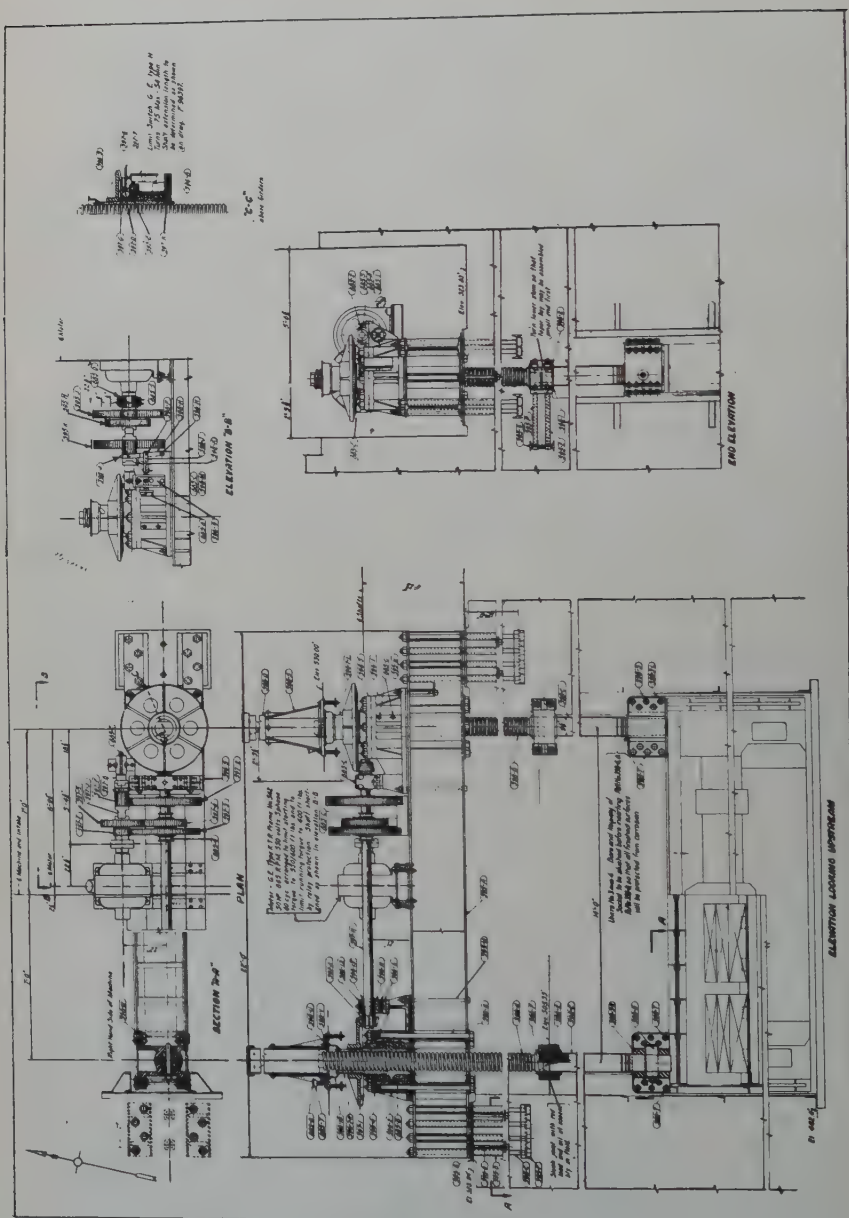


FIG. 6. — HEAD GATE HOIST

position. The rectangular gate openings are connected to the 15' 0" diameter steel penstocks by short concrete taper sections.

The trash racks are made up in twelve separate sections for each bay and operate in vertical guides. The clear opening between rack bars is 4 in. Guides for mechanically operated rack rakes have been provided so that the rakes may be installed later if found necessary. Provision is also made for the introduction of compressed air, both at the bottom of the trash racks and under the head-gate sills.



FIG. 7. — UPSTREAM FACE OF DAM

Intake structure in foreground. Looking southeast from Alabama side of river

The intake stop-log slots are upstream from the trash racks, so that all equipment in each bay may be reached if necessary. The eight stop-log sections provided are stored two in each bay, and in this position extend far enough below normal water level to form a cut-off wall in front of the intake.

Bays No. 1 and No. 2 at the east end of the intake are used for the initial installation and are completely equipped. Bays No. 3 and No. 4 at the west end have head gates installed, but gate hoists and trash-rack sections have been temporarily omitted. (Fig. 7. Upstream

Face of Dam.) Partial provision for a fifth unit has been made by designing the west wall of the intake so that a possible fifth penstock can be added outside this wall with only a slight alteration in the concrete structure.

At the downstream face of the intake two small concrete buildings have been constructed between the buttresses. One of these contains the pumping units which supply the camp water system. The second houses the circuit breakers and other electrical control equipment for the gate-hoist motors.

A floating boom to deflect logs and other débris has been fastened across the intake so that it extends from the upstream end of the wing wall at the west side of the intake to the intersection of intake and dam. This boom is braced and trussed so as to form a semi-rigid structure and supports a wooden walkway. The ends are secured to the concrete by sliding anchorages, so designed that the boom can rise and fall with the reservoir level.

Material stopped by this boom can be floated over towards the spillway and disposed of through the skimmer gates.

PENSTOCKS

Supplying each of the initial units there is a steel penstock 15' 0" in diameter and about 300 ft. long. The size of these penstocks was determined largely with a view to keeping the speed change and pressure rise within proper limits.

These penstocks were designed to fit the ground as nearly as possible and at the same time enter the power house at equal angles so as to make the connections to all generating units identical. At all vertical and horizontal angles the penstocks are anchored with massive blocks of concrete. At other points they are supported on reinforced concrete saddles about 9 ft. apart, the tops of which extend very nearly to the horizontal center line of the pipe. These saddles are designed to resist the distorting effect of a pipe just full of water so that the penstocks can be filled and emptied without material change of shape.

The pipe shell itself is made of steel plates varying in thickness from $\frac{1}{2}$ in. to $\frac{1}{16}$ in. and stiffened with $6'' \times 3\frac{1}{2}'' \times \frac{1}{2}''$ girth angles.

These stiffener angles are spaced alternately between and over the saddles, those between saddles being carried all the way around the pipe, and the intermediate ones extending only to the tops of the saddles. Both penstocks are backfilled.

The penstock for No. 1 unit lies close to the training wall which con-

nects the intake with the power house. The saddles of this penstock are therefore extended to form buttresses for the wall, with a mutual increase in stability, and some saving in material.

POWER HOUSE

The power house is located on the west bank of the river about 300 ft. downstream from the intake. The present building is about 90' x 80' in plan, with a unit spacing of 42' 8". The substructure is of reinforced concrete, and the superstructure is of brick with a structural steel frame. (Fig. 8. Cross Section of Power House.)

The substructure is founded on solid rock which was excavated under the wheel pits down to Elev. 382. It forms the supporting and foundation block for the generating units, and has three levels: the drain-valve pits and drain gallery at and below Elev. 401; the turbine deck at Elev. 521.5; and the generator floor at Elev. 533. Since the water wheels are equipped with riveted steel scroll cases, the structural design of the substructure presents no unusual features. The generator floor is a 24-in. slab without beams but with reinforcing bars placed in bands over the supporting piers. The floor is designed to support a railroad track and a movable live load equivalent to the largest outdoor transformer. This flat slab construction has the advantages of easily accommodating conduits, simplifying form construction and furnishing a plane surface for supporting pipes and other equipment on the floor below.

The superstructure comprises all of the power-house building above Elev. 433. It is divided longitudinally into two main compartments, — the generator room, 47 ft. wide, and the electrical bay, 25 ft. wide. The generator room is 47 ft. high and extends to the roof, containing the generators, a few pieces of auxiliary equipment and the station crane.

The electrical bay includes two floors above the 433 generator floor level, one at Elev. 450 and the other at Elev. 464. At Elev. 433 are located the station service switchboard and accessories, the low tension bus compartments and a locker room. At Elev. 450 are the station switchboard and control room, the battery room, and additional bus compartments. The 464 level is given up to storage and office space.

The roof, floor and live loads are carried by the structural steel frame. The building has a flat tar and gravel roof which is supported on steel roof trusses over the generator room and on steel beams across the electrical bay. The walls are common brick with cast-stone copings and belt courses.

The west end of the building is closed by a temporary wall, similar in appearance to the rest of the building, but so constructed that it can be readily removed when it becomes necessary to extend the station. A large double door in this wall will allow loaded railroad cars to be brought into the building at the level of the generator floor. A standard gage railroad spur connects the power house with the outdoor substation and with a branch railroad line which was built and used as a construction railroad.

Drainage of the roof and all floors above and at Elev. 433 is taken care of through a central drainage system leading to the river below the water level. The floors at and below Elev. 421.5 drain to the gallery over the draft tubes. In this gallery is a sump in which are installed one motor-driven pump and one ejector operated by penstock pressure. Both are float-controlled.

HYDRAULIC EQUIPMENT

The water wheels, governors, oiling system and appurtenances were furnished by the S. Morgan Smith Company of York, Pa. They are of the single-runner vertical Francis type, with riveted-steel scroll cases. Each wheel is guaranteed to develop 22,000 h.p. when operating at best efficiency under a head of 112 ft. The synchronous speed of the units is 150 r.p.m. (Fig. 9. Assembly of Turbine Runner, Shaft and Housing.) The runners, speed rings and wicket gates are cast steel; the curb rings, cover plates, bottom plates, bearing housings and pit liners are cast iron; while the scroll cases and draft-tubeliners are plate steel. The specific speed of the runner is 61. Each wheel has one steady bearing of the babbitted type, designed for oil lubrication. Leakage by the runner clearances is drained through the speed ring columns to the draft tube.

The draft tube is of the elbow type but modified to provide a flattening at the turn, with a corresponding increase in width in a direction parallel to the longitudinal axis of the power house. The particular draft tube design used was adopted as the most efficient after extensive tests upon model tubes at the manufacturer's laboratory. The draft tube seal is submerged 7 ft. below minimum tailwater level.

The water wheel governors are of 120,000 ft. lbs. capacity each, and are operated by means of oil pressure of 175 lbs. per sq. in. The governor oil system is laid out on the unit plan. One governor, pressure tank, sump tank and oil pump are used to operate each water wheel. There is in addition one spare oil pump which is cross connected in

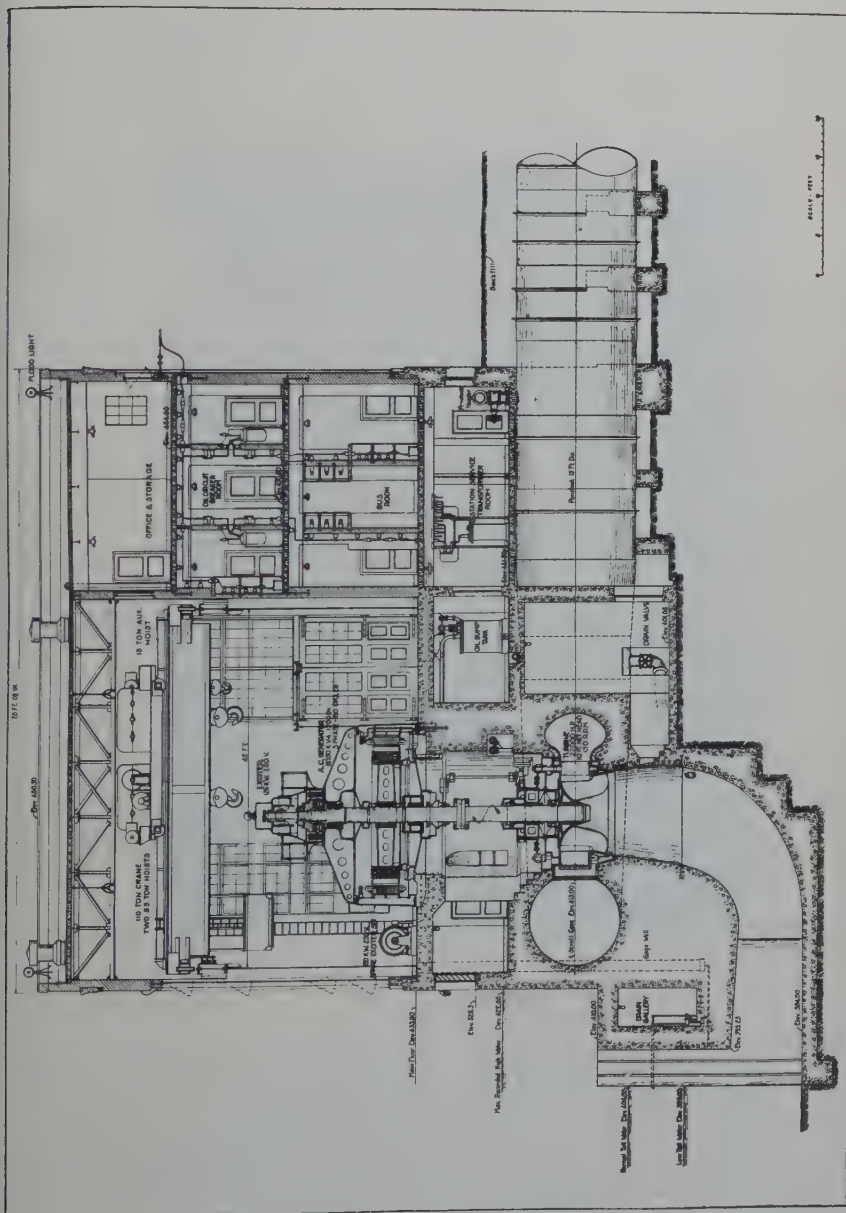


FIG. 8. — CROSS SECTION OF POWER HOUSE

such a way that it can be substituted for any of the other oil pumps in the present or future installation. (Fig. 10. Scroll Case Erection.)

The governor-oil and lubricating-oil systems for both water wheel and generator are connected together and the same oil used throughout

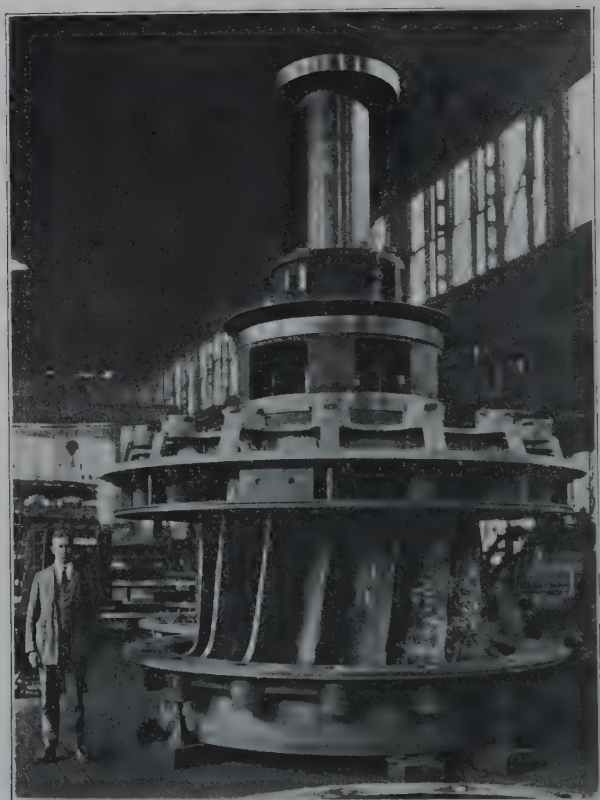


FIG. 9. — ASSEMBLY OF TURBINE RUNNER, SHAFT
AND HOUSING

so that the lubricating systems may be filled from the governor-oil system if necessary. Provision is also made for filtering oil from any part of either system by means of a receiving tank and filter located in one of the valve pits. Oil from the generator bearings may either be returned to a sump tank, passed through the filter, or wasted down a draft tube. The oil pumps are of the Quimby screw type and are motor-driven.

ELECTRICAL EQUIPMENT

The alternating current generators which are of the vertical type, direct connected to the water wheels, were furnished by the Westinghouse Electric and Manufacturing Company. Each generator is rated 18,750 kva. at 80 per cent power factor, 12,000 volts, 3 phase, 60 cycles, 150 r.p.m. Each generator has a Kingsbury thrust bearing and two guide bearings. A direct connected exciter, rated 125 kw., is mounted above the thrust bearing on each unit. A motor-driven spare exciter is also provided.

Each thrust bearing runs in an oil bath contained in the bearing housing and cooled by circulating water. Separate lubrication for the guide bearings is obtained by circulating oil through both bearings by means of a small oil pump driven from the generator shaft.

The generator neutrals are solidly grounded through a neutral bus. Differential relay protection is provided. The generators are cooled by drawing air from the generator room and discharging it through the generator pit and openings in the outside wall immediately above the tailrace. This reversal of the usual cooling arrangement is to insure a cool station during hot weather.

The control switchboard is located in a room at the 450 level which has a bay window overlooking the generator room. The switchboard is a benchboard of four panels on which are mounted the instruments and the control for the generators, exciters and 12 kv. and 110 kv. feeders. The relay and metering equipment is mounted on a vertical board directly behind the benchboard.

The station service switchboard is located in a room immediately below the control room, but the important station service circuits are remote-controlled from the main control room. A single 12,000-volt generator bus is provided for the switching of the generator and station service power, and there is a single excitation bus for switching the spare exciter.

The generator bus is located at the generator floor level with the main circuit breakers on the floor directly above. These breakers are solenoid-operated with a normal rating of 1,600 amperes and a rupturing capacity of 24,000 amperes at 12,000 volts.

The 575-volt station service power is obtained from two transformer banks each consisting of three single-phase transformers. The station auxiliaries are controlled by double throw switches adjacent to the motors, the motors having two distinct sources of power from the station service switchboard. The motor-driven auxiliaries at the

dam also have two sources of power distributed through a service room at the intake.

The control battery is installed on the first floor above the generator level, and has a normal rating of 40 amperes at 125 volts. Two motor-driven charging sets are located adjacent to the battery.

The station lighting is obtained from a 50 kva. transformer rated 575 to 220/110 volts. Emergency lighting is obtained by automatic

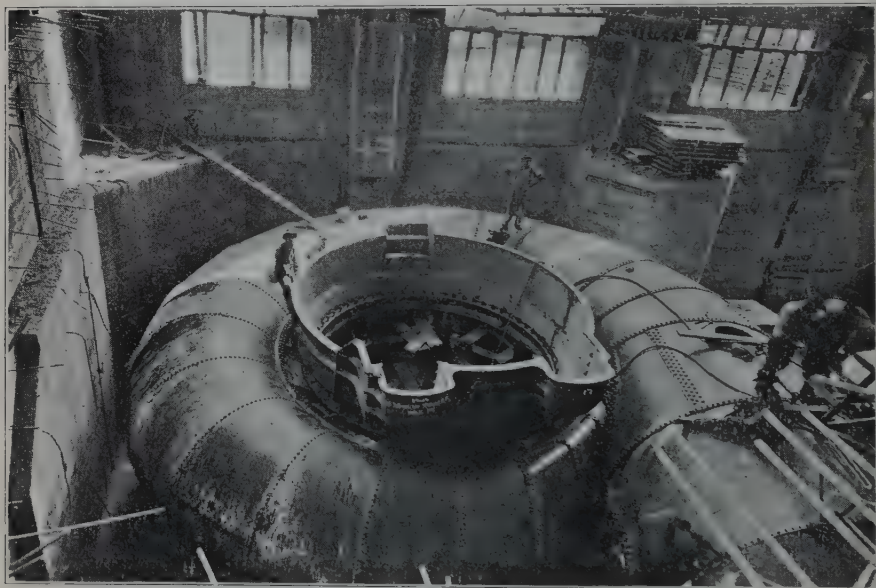


FIG. 10. — SCROLL CASE AND PIT LINER — WATER WHEEL No. 1

switching from the lighting transformer to the 125-volt control battery. The dam is lighted by means of flood lights on the gantry crane and by flood lights located at the top of the generating station. Local lighting is provided for the walkway on the training wall, the intake and the inspection gallery through the dam.

Provision is made for electrically heating the electrical bay. For heating the generator room provision is made for recirculation of the air from the generators. This recirculation is obtained by closing louvres in the air passageway from the generator pit and passing the air through openings in the generator-room floor.

From the electrical bay to the substation there will be two power

feeders carried overhead on steel supports. The conductors are 750,000 circular mils bare stranded copper cable. (Fig. 11. Feeder Line and Power House.)

POWER HOUSE CRANE

To handle the generator rotor and shaft requires a crane capacity of 110 tons. If a crane with a single hoist had been used, however, it would have been necessary to increase the height of building in order to have sufficient clearance to lift the rotor and shaft over the top of the



FIG. 11. — FEEDER LINE AND POWER HOUSE

Looking northwest with dam in background

stator ring. This is because with a single hoist the crane hook must be brought into a position directly above the top of the generator shaft. To avoid this a double hoist was adopted, with twin hooks, which engage the ends of a lifting beam. This beam is designed to slip down over the generator shaft and bears against a split ring key which is bolted on the shaft after the lifting beam is in place. This arrangement permits the hooks to be brought down a considerable distance below the top of the shaft which is allowed to project upwards between the bridge girders of the crane.

SUBSTATION

The outdoor substation is located about 300 ft. from the generating station. It consists of an open steel structure of three bays, each 44 ft. wide, 105 ft. long and 66 ft. high, and contains the power transformers, 110,000-volt oil circuit breakers, lightning arresters, and instrument transformers. The substructure is of reinforced concrete construction, and to fit the topography of the site is built in three terraces. The power transformers are located on the lower terrace, the circuit breakers



FIG. 12. — SUBSTATION

Looking south from concrete mixing plant

on the intermediate terrace, and the lightning arresters on the upper terrace. (Fig. 12. Substation.)

Each of the two 12,000-volt power circuits is connected directly to a bank of three single-phase transformers Y connected, which step the voltage up to 110,000 volts. These transformers were manufactured by the Westinghouse Electric and Manufacturing Company and are water-cooled. There is one spare transformer which is kept on a transfer truck on the transfer track at the substation. This transfer track is standard gage and is connected with the railway track which enters the generating station.

The 110,000-volt circuit from the transformer bank is connected through oil circuit breakers to a single bus. Three 110,000-volt feeders are connected to the 110,000-volt bus by means of oil circuit breakers, which are shunted by pole top switches.

The 110,000-volt oil circuit breakers are the Westinghouse type G-222. They are solenoid-operated, normally rated at 400 amperes and have a rupturing capacity of 7,650 amperes at 115,000 volts. They are remote-controlled from the main switchboard in the generating station. Provision has been made for the future extension of the substation to accommodate a total of eight 110,000-volt feeders.

RAILROAD AND HIGHWAY CHANGES

Owing to the submergence in the reservoir of previously existing structures, it was necessary to relocate and reconstruct two railroad bridges, five highway bridges, $2\frac{3}{4}$ miles of railroad and $2\frac{1}{2}$ miles of highway. Most of these crossings involved much larger structures than the original bridges.

The railroad bridges are of the deck plate girder type. One has two spans of 30 ft. and four spans of 70 ft. each, and the other has two spans of 30 ft. and three spans of 70 ft. each. These bridges have approach fills which required extensive riprapping to protect them against wave action.

Three of the four highway bridges have three spans each. The center opening in each case is a truss span from 100 to 160 ft. in length, with two shorter side spans carried on steel beams. The other highway bridge has four truss spans. Concrete piers and abutments are used for all bridges.

CONSTRUCTION PLANT LAYOUT

The camp and most of the construction plant were located on the Alabama side of the river in order to secure adequate connection with outside railroads. This was obtained by constructing $4\frac{1}{2}$ miles of standard gage single-track railroad from Bartlett's Ferry to Halawaka, Alabama, a point on the Chattahoochee Valley Railroad.

The layout of both camp and construction plant was carefully planned. The camp buildings were, in general, located back from the river on high ground. These buildings were of the usual frame construction and included offices, living quarters, mess halls, warehouses, shops, bunk houses, commissary, bathhouses, stables, garages, clubhouses, schoolhouse and a hospital. Separate accommodations were provided for white and colored labor.

Water for the camp was obtained from the Chattahoochee River, there being no other convenient source of supply. For this purpose a complete water-purification plant was installed, including chlorinator, settling tanks, and filters in accordance with the requirements of the Alabama State Board of Health.

The railroad was laid out so as to provide one set of tracks at a low level and one set at a high level. The low-level track served all parts of the actual power site, and also the quarries, rock crushers, and sand plant, while the high-level track gave access to the storage yards, warehouses and mixing plant. The two levels met at a junction west of the camp.

Handling of material from the track to the various structures was by means of steel derricks, of which there were usually seven or eight in place at all times.

An important construction problem was the unwatering of the site. In this case the river was diverted first from the west side and later from the east side of its bed by means of rock-filled timber crib cofferdams. These unwatering operations were carried on in three stages.

First, a cofferdam was constructed to include the west half of the dam and the entire power house site. This cofferdam was 1,200 ft. long and had a maximum height of about 30 ft. Its upstream arm was composed of a timber crib about 30 ft. wide, sheeted on the upstream face, with a clay fill deposited against this sheeting and sloping upstream at about $2\frac{1}{2}$ to 1. The arm of the cofferdam extending downstream in a direction parallel to the current was exposed to scour, and on that account an unprotected clay toe to provide water-tightness could not be used. This arm of the cofferdam was, therefore, built double with two separate cribs built 8 ft. apart, both sheathed on the inside face and having clay puddle between. (Fig. 13. Cofferdam and Construction Plant.) After pumping out this cofferdam the flow of the river passed entirely between its east end and the east bank. This structure was designed to pass floods up to 40,000 c.f.s., which do not ordinarily occur more than two or three times in an average year. However, after the cofferdam had been unwatered and excavation begun, a flood of over 100,000 c.f.s. took place. This was the second largest flood recorded in thirty years and did considerable damage along the river. Water soon poured into and filled the cofferdam area and steadily rose until it topped the upstream cribs by more than 9 ft. The structure was not seriously damaged, however, beyond the loss of considerable clay puddle, and after the flood subsided it was again unwatered and excavating resumed. This is an excellent example of the advantages of build-

ing a cofferdam which is strong enough to resist more than the expected flood conditions. Had this structure been less substantially built it might have been completely destroyed with the loss of much valuable material and time.

The portion of the concrete spillway within the first cofferdam was constructed to above ordinary high water level. In this block of concrete, however, a gap was left large enough to pass ordinary summer floods. Six large rectangular sluiceways were also left open, with twelve



FIG. 13. — COFFERDAM AND CONSTRUCTION PLANT

timber flap gates so arranged that each sluiceway could be closed by dropping two of the gates.

The second step in the diversion of the river was to tear out the first cofferdam and construct a second cofferdam between the end of the concrete block and the east bank of the river. The water was passed through the openings in the concrete already in place at the west side of the river bed. Concrete was then poured in the east part of the dam to above high water level.

During the third stage in the diversion of the river concrete was poured in the gap previously left in the west portion of the spillway, thus compelling the entire stream flow to pass through the temporary

sluiceways. During periods of flood the water rose nearly to the top of these openings, but was passed through without difficulty. (Fig. 14. General View Looking Upstream.) On December 1, 1925, final closure was made by dropping the control gates. Owing to dry weather the reservoir required more than three weeks to fill, but on December 22



FIG. 14. — GENERAL VIEW LOOKING UPSTREAM

water flowed over the spillway crest. During the period of reservoir filling the plants downstream were kept in operation by passing water through the four permanent sluiceways previously described.

CONCRETE MATERIALS

Sand for the concrete was obtained in large part from a sand bar in the river a few hundred yards downstream from the dam site. This sand varies somewhat in composition, depending upon its location in the bar, and contains a certain amount of silt. The sand was pumped from the bar into elevated bins, thus washing it *en route* to the mixers. Some difficulty was at first encountered in securing sand of the proper size and grading, but by exploring different parts of the bar a location for the pumps was finally found which gave a very satisfactory product.

Coarse aggregate for the concrete was obtained partly by quarrying and crushing the local rock and by purchasing gravel in the market near

by and transporting it to the site. Gravel was used for the greater part of the work.

Concrete materials were transported by rail from the crushers and bins or from the storage piles to the concrete plant, which was constructed on a side hill in such a way that cars could be run over the bins, which in turn were directly above the mixers. Two 4-yard mixers were used, but the batches usually contained about $3\frac{1}{2}$ cu. yd. each. Concrete was moved from the mixers on railroad cars to within reach of the steel derricks, which were used to place the concrete in the forms.

The total concrete in the job amounted to about 180,000 cu. yd., of which about 5 per cent was plum stones. The bulk of this yardage was placed in seven months, between March 1 and September 30, 1925. During the one month of August, 45,000 cu. yd. of concrete were placed, an average of over 1,700 cu. yd. per working day. The concrete material handled in August required 1,810 cars to transport it. The total area of concrete forms was over 740,000 sq. ft.

CONCRETE SPECIFICATIONS

The specified proportions for mixing concrete were approximately 1:3:6 for the mass concrete in the main spillway and retaining walls, and approximately 1:2:4 for all reinforced concrete. These proportions, however, served merely as a rough indication of the mix to be used, as it was intended to secure concrete of a definite compressive strength rather than of fixed proportions. The mass concrete was required to have a strength of 1,000 lbs. per sq. in. at seven days, and 1,500 lbs. at twenty-eight days, and the reinforced concrete to be good for 1,250 lbs. at seven days and 2,000 lbs. at twenty-eight days.

Preliminary tests were made with a view to determining workable mixtures which would give the desired strengths with a minimum amount of cement. These mixtures were later changed somewhat to suit varying conditions and also to meet the practical requirements of construction operations. It was found, for example, that to facilitate the rapid handling and placing of large quantities of wet concrete, a slightly greater amount of water was necessary than is required for the ideal "dry mix."

RESERVOIR CLEARING

In order to satisfy the requirements of the Federal Power Commission and the State Boards of Health, it was necessary to clear entirely the flooded area between the limits of highest flood and lowest expected drawdown. It was also necessary to cut all trees whose tops projected

above the drawdown level. The total area cleared was about 4,200 acres.

Owing to the nature of the tree growth, the task of clearing this area presented one of the most difficult problems encountered in the entire development. Except for construction requirements there was no market for the lumber. Brush could be cut and burned, but most of the tree trunks would not burn because they could not be dried out sufficiently. It was, therefore, necessary to dispose of all unburned logs



FIG. 15. — DOWNSTREAM FACE OF DAM
Discharge of over 25,000 second feet passing over dam

either above or below the cleared area. Logs which were hauled down hill within the reservoir had to be prevented from rising to the surface when the reservoir was filled. This was accomplished by tying down all such logs with heavy wire. This being a novel and unusual procedure some doubt was felt as to the outcome. The results, however, have justified the methods adopted, since after the reservoir had been filled very little drift appeared at the dam.

In addition to the clearing operations just described the Federal Power Commission also required that the reservoir be stocked with top feeding minnows as a protection against the breeding of mosquitoes.

This was done by constructing and stocking a series of fishponds on the reservoir slopes which were subsequently flooded out with the rise of the water. (Fig. 15. Downstream Face of Dam during Small Flood.)

DRAWINGS

Work on construction drawings was started in the Boston office in the spring of 1924 and within a year over 90 per cent of the required drawings had been completed. The total number of final drawings made was about 430, exclusive of study sheets and bills of material. About 70 draftsmen were employed on this work at the period of greatest activity.

CONSTRUCTION OPERATIONS

The largest number of men employed on the work at any one time was about 2,400, of which 1,900 were at the Bartlett's Ferry camp and the balance scattered about on auxiliary operations in the reservoir and elsewhere.

The total cement used amounted to about 215,000 barrels. Several miles of standard gage railroad track were built. The construction plant used included the following principal pieces of equipment:

10 steel 20-ton capacity guy derricks and hoists	32 wagons
5 power shovels	4 compressors
11 locomotives	2 four-yard concrete mixers
2 locomotive cranes	18 four-yard concrete buckets
62 railroad cars	1 large jaw crusher
4 heavy and 9 light tractors	3 gyratory crushers
10 motor trucks	32 pumps

In May, 1924, a start was made on actual construction work. A few camp buildings were erected and work commenced on assembling plant and materials. To furnish a power supply for the new work a transmission line was constructed, extending from the Goat Rock station to the new power site. Cofferdam construction was started early in August, and excavation for the foundations of the dam was begun in October, 1924. In March, 1925, the first concrete was poured in the dam. Owing to the unusual floods the earlier part of the construction operations fell somewhat behind the initial schedule, but during the summer of 1925 conditions were more favorable. By the end of the year the bulk of the work had been completed practically in accordance with the original schedule, and on January 25, 1926, the first unit was put into commercial operation. It is expected that the second unit will go into commercial operation on March 1, and that the entire development will be completed a few weeks later.

OF GENERAL INTEREST

THE ENGINEER AND PUBLIC HEALTH

Abstract of an Address Delivered by Dr. George E. Vincent,
President of the Rockefeller Foundation, at a Joint Meeting
of the Boston Society of Civil Engineers and the
Sanitary Section, B. S. C. E., on January 27, 1926.

The subject of public health is of interest to very many people, especially just now when the tendency seems to be to lay stress upon disease prevention. We hear a great deal about man's control of disease through science, of the new achievements in medicine, and we think that the hygienic millennium must be about to dawn. But when we consider what is yet to be done, we realize that this millennium is far distant. However, there has been definite, measurable accomplishment.

In New York City in 1885 the general death rate was about 20 per thousand, and the infant mortality rate — those dying in the first year of life — was 254 per thousand. At the present time the general death rate in that city is about 12 per thousand and the infant mortality about 68 per thousand. These are heartening figures; they show that things have been radically bettered. The improvement, however, must be credited to a variety of causes, among which purposeful health work is only one.

There is an order, and a very proper order, for the development of public health work in any community. It follows three stages: the sanitation of the physical environment, the control of

communicable diseases, and the stage of hygiene, — general personal hygiene, maternal hygiene, infant hygiene, school hygiene, industrial hygiene and mental hygiene. The three stages do not always appear in this chronological order.

In 1885 tenement house conditions in New York were execrable. In the yards of many of the lower type of tenements there were open latrines exposed to the disease-transmitting fly. The streets were rarely cleaned. But these things were changed. Colonel Waring came into action, improving and repaving the streets and keeping them clean. New tenement house laws were enforced requiring better sanitary arrangements. Milk supplies were improved and foods inspected. Therefore two of the causes from which infants die — affections of the alimentary tract and of the respiratory system — were obviated to a great degree by sanitation within the homes and by the care of the streets. Other factors have contributed to the decrease in infant mortality, such as the work of the health center — particularly the baby centers — and increased knowledge of hygiene.

In the case of communicable diseases, too, a great deal has been accomplished.

Typhoid fever, smallpox, malaria, and yellow fever are now understood, and the methods of controlling them have been worked out. Diphtheria has been brought under control and probably can be almost if not completely banished. And it looks as though something might be done about scarlet fever. There are other diseases, such as measles and influenza, that we as yet know little about.

Personal hygiene is being much emphasized today. Enthusiasts convey the impression that all we need to do to prolong life is to discover our diseases early enough by having periodic physical examinations, and to follow a proper régime of diet, exercise, and mental hygiene. Unfortunately other factors must be taken into consideration, — heredity, for instance, and social environment.

You will notice that there is a tendency to lay great stress on either one or the other of these. At one time everything is laid to heredity, at another to environment. As a matter of fact, it is both all the time. When it comes to matters of health there seems to be no escaping the fact that some people are wound up to run longer than others. Some will run for twenty-four hours and some for ninety years. And in this it is believed that heredity plays an important rôle. But it isn't wise to depend too much on heredity — to say, "My ancestors lived to be over ninety, I don't need to take care of myself." We must keep the dust and sand out of the wheels, and keep them lubricated.

Other considerations, too, must be taken into account. There are many chronic diseases to which people fall prey. To hold out hope that these can be cured by following the precepts of hygiene would not be right. A man may, for example, escape having heart disease if he takes proper care of himself; but when he has once contracted it, we can-

not honestly hold out any encouragement that he can be cured by hygienic measures. The control of cancer has its possibilities. The recent investigations in this field have been valuable and significant, but to say that they have produced results of undoubted therapeutic value is one of the cruelest things that can be done. The essential thing is the education of the public to the importance of early recognition of these malignant growths, so that surgical and other remedies may be employed when they are in their first stages.

Much, then, remains to be done along the line of personal hygiene. Mental hygiene has been neglected, and this is a most significant field, warranting extensive study. Maternal hygiene is fortunately on a much better basis. Maternal mortality has been greatly reduced. In the United States it is now 6 per thousand, and in Great Britain 3 per thousand; in Holland, less than 2.

In the field of child hygiene, medical inspection of school children is playing an important part. The pupils receive a yearly physical examination, their defects are noted, and effort is made to have these defects remedied. In industrial hygiene improvement has been especially noteworthy. Many commercial organizations now provide a complete system of hygienic care for their employees, and this service they consider not so much philanthropy as good business.

To this great health movement which has been going on, the engineer has contributed largely. A recent study of the death rate in Massachusetts, from early times down to the present, showed that the tremendous fall in this rate was synchronous with the introduction of water supplies in the state. The water supply is, of course, correlated with sewage disposal and the care of other wastes. There is no doubt whatever that these things affect the death rate. This has been well

illustrated in the sanitary history of Massachusetts, in which the engineer may justly take pride.

In another branch of health work in which great progress has been made, the sanitary engineer has played a prominent part. This is the control of malaria. In many areas the public health officer has been able to bring this disease under control by minor drainage projects and other simple antimosquito measures; but in certain other regions problems have been encountered whose solution has required a high degree of engineering skill.

The sanitary engineer, then, has rendered and may continue to render a great service to public health work. He has had scientific training; he knows the meaning of the scientific attitude. He knows the importance of applying scientific truths to the problems of the community and the importance of educating the public mind. With such knowledge he can play a most important rôle in his own community, standing for the things that are sound, for expertness that has been thoroughly tested.

As engineers you are to be congratulated on what you have achieved. You are to be congratulated upon having had a fundamental part in the sanitation of the environment. This is the first step in any public health program; its neglect vitiates the whole system of group hygiene.

In your work you may be confronted by a citizenship with all kinds of illusions and many absurd ideas. You must have the grit, character, and independence to say what you think and to stand up for it. A few people may accomplish much in a community. It is only when we lie down and let things roll over us that we have chaos and ignorance and futility. When even one man can stand up for what he thinks true and right something will be accomplished.

Reprints Available

A limited number of reprints of articles published in the JOURNAL of the Boston Society of Civil Engineers are available and may be obtained on request at the rooms of the Society, 715 Tremont Temple, Boston. These will be furnished free with the exception of the Report of the Committee on Run-Off, the price of which is 25 cents.

"Fire Protection in Building Design."

E. A. Barrier and J. O. Taber.

"Plant for Degreasing of Wool-Scouring Wastes." *G. G. Bogren.*

"Supports for Superimposed Stocks." *W. W. Clifford.*

"Hydrogen-Ion Control in Chemical Treatment of Tannery Wastes." *S. E. Coburn.*

"Construction of Neponset Bridge." *J. S. Crandall.*

"New England Power Company—Davis Bridge Development." *A. C. Eaton.*

"Control of Oil Pollution in Rhode Island." *S. D. Gage.*

"Indictment and Suits Against Cantonment Constructors." *F. M. Gunby.*

"What Shall be Done to Secure Better City Planning?" *G. H. Nye.*

"Flood Flows of New England Rivers." *C. H. Pierce.*

"Precise Leveling in New England." *E. B. Roberts.*

"Amoskeag Manufacturing Company Hydro-Electric Development." *A. T. Safford.*

"In Memory of Samuel E. Tinkham."

"Inverted Siphons for Sewers." Report of Committee of Sanitary Section, B. S. C. E.

"Symposium on City Pavements."

"New England Railroad Problem." Report of Committee of Affiliated Technical Societies of Boston.

"Power Requirements and Sources of Supply for New England" (based on Report of Committee of Associated Industries of Massachusetts).

"Report of Committee on Run-Off" (price of this publication is 25 cents).

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETINGS

BOSTON SOCIETY OF CIVIL ENGINEERS

FEBRUARY 17, 1926. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, Boston, and was called to order by the President, Richard K. Hale, at 7.20 P.M. There were about 300 members and guests present.

This was a Joint Meeting of the Boston Society of Civil Engineers; Northeastern University Section, B. S. C. E.; M. I. T. Student Chapter, American Society of Civil Engineers; Harvard Engineering Society; and Tufts Civil Engineering Society.

The reading of the minutes of the previous meeting was omitted as they will be printed in the February JOURNAL.

The Secretary announced the names of those elected to membership by the Board of Government today as follows:

Members: George G. Bogren,* Ovidio D. Chiesa,* Walter G. Classon, George T. Gallagher, James Luchini, Frederic N. Weaver, James W. Woodhall. *Juniors:* Julius Abrams, Walter C. Bailey, Frank L. Cheney.

The President announced the death of Leonard Metcalf, Past-President of the Society, on January 29, 1926. He stated that a committee would be appointed to prepare a memoir.

General Hale then introduced Mr. H. A. Hageman, Hydraulic Engineer of Stone & Webster, Inc., who presented an illustrated paper on the "Bartlett's Ferry Hydroelectric Development." This paper, prepared jointly by Mr. Hageman and Mr. T. B. Parker of Stone & Webster, Inc., described a development on the Chattahoochee River, which is now being completed by Stone & Webster, Inc., for the Columbus Electric and Power Company of Columbus, Georgia. The ultimate ca-

capacity will be 60,000 kw. in four 15,000 kw. units, each driven by a water wheel designed to develop 22,000 h.p. under a 112 ft. head.

The slides illustrated construction drawings and numerous photographs taken during the progress of the work. In addition to describing the general layout and features of design, Mr. Hageman gave much interesting data concerning the plant and the methods of carrying on the work. The subject proved of great interest to the large number present.

After Mr. Hageman had answered a number of questions concerning the development, the meeting adjourned about 9.30 P.M.

The meeting was preceded by a Buffet Supper and Smoker. The Northeastern University Band of about 25 pieces played during and following the supper. There was also singing by various college groups before the meeting started.

J. B. BABCOCK, *Secretary.*

SANITARY SECTION

JANUARY 27, 1926. — A special meeting of the Sanitary Section was held jointly with the main Society at the regular meeting of the latter on Wednesday, January 27, 1926, in Chipman Hall.

The meeting was called to order at 7.25 P.M. by Vice-President C. B. Breed, who introduced Chairman E. S. Chase of the Sanitary Section. Mr. Chase, after a few remarks, introduced Dr. George E. Vincent, President of the Rockefeller Foundation, who spoke upon "The Engineer and Public Health." He discussed various health and death rate statistics and pointed out the important part that the engineer has had in the betterment of public health conditions. Dr. Vincent's address was broadcast through station WSSH, Tremont Temple. At the close of

* Transferred from grade of Junior.

his talk, Dr. Vincent was given a rising vote of thanks. The meeting was then opened for general discussion.

There were 120 present. The meeting adjourned at 8.30 P.M.

R. W. HORNE, *Clerk*.

FEBRUARY 3, 1926. — A special meeting of the Sanitary Section was held in the library of the Affiliated Technical Societies, Wednesday, February 3, 1926. Preceding the meeting 28 members of the Section met at Marston's Dining Room for dinner.

The meeting was called to order by the Chairman at 7.15 P.M. Reading of the minutes for the previous two meetings was omitted, there being no objection. It was duly voted that the Chairman appoint a nominating committee to prepare a slate of officers for the coming year. Messrs. Fair, Coburn and Barbour were appointed to serve on this committee.

The Chairman announced the death of Mr. Leonard Metcalf and the meeting arose for a minute of silence in respect to his memory.

Professor Earle B. Phelps of the College of Physicians and Surgeons, Columbia University, was then introduced. Professor Phelps read a paper on "Chlorination of Water and Sewage." Following the paper there was considerable discussion in which the following took part: Messrs. Tyler, Weston, Pratt, Dorr, Doane, Fair, Wright, Fales, Howard and Pincus.

There were 39 present at the meeting. Adjourned at 8.30 P.M.

R. W. HORNE, *Clerk*.

APPLICATIONS FOR MEMBERSHIP

[March 15, 1926]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

For Admission

BRIGGS, LEON ROBERT, Adams, Mass. (Age 23, b. Adams, Mass.) Graduate of Adams High School. At present a junior at Northeastern University. During work periods has been employed by Aspinwall & Lincoln. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

FITTS, CHARLES A., Boston, Mass. (Age 21, b. Northampton, Mass.) Graduate of Amherst High School. At present a junior at Northeastern University. During work periods has been employed by Aspinwall & Lincoln. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

HANSON, ERLING A., Boston, Mass. (Age 21, b. Boston, Mass.) Graduate of English High School. At present a senior at Northeastern University. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

MARTIN, ARTHUR D., Boston, Mass. (Age 23, b. Montgomery, Vt.) At present a student at Northeastern University. During work periods has been employed by Whitman & Howard and by town of Brookline. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, G. A. McKenna, G. H. Melcher, W. E. Nightingale.

TERZAGHI, CHARLES, Cambridge, Mass. (Age 42, b. Prague, Czecho-Slovakia.) Graduate of Technische Hochschule, Graz, Austria. 1906-09, superintendent of construction of reinforced concrete buildings and water power plants; 1909-

11 in charge of hydrographic and geological survey for 25,000 h.p. water power development in Croatia; 1911 obtained degree of Doctor of Civil Engineering at Technische Hochschule in Graz; 1912-14 in various capacities in western United States, studying American methods of handling earthwork and foundation problems; 1914-16 in Austrian air service; 1916-18 professor of foundation engineering at the Turkish University in Constantinople; 1918 to date, associate professor, and later head of department of civil engineering at Robert College, Constantinople; since July, 1925, on leave of absence from Robert College, lecturer at Mass. Inst. Tech. Refers to J. B. Babcock, H. L. Bowman, J. R. Freeman, C. M. Spofford, Hale Sutherland.

WILSON, HERBERT ALBERT, West Roxbury, Mass. (Age 21, b. Boston, Mass.) At present a senior at Northeastern University. During work periods has been employed by Henry F. Bryant and Boston & Albany R.R. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

For Transfer from Junior

LEE, WALTER H., Dorchester, Mass. (Age 28, b. Boston, Mass.) Graduate of Northeastern University, 1922. Experience since then as follows: Assistant secretary, New England Road Builders Assn. in 1923 and 1924; assistant superintendent, Lane Construction Corp., 1925; and president, Lee Crane Service Co., 1926. Refers to H. B. Alvord, A. B. Appleton, L. G. Brackett, A. W. Dean, C. S. Ell, W. E. Nightingale.

MUESER, WILLIAM H., New York, N. Y. (Age 25, b. New York, N. Y.) Graduate of Mass. Inst. of Technology, 1922; post-graduate studies at the Technische Hochschule zu Berlin, Charlottenburg, Germany, 1922-23; Nov. 1, 1923, to date as designing, and later chief designing engineer for Moran, Maurice & Proctor, consulting engineers in foundations and substructures. Refers to J. B. Babcock, C. B. Breed, K. C. Reynolds, C. M. Spofford, Hale Sutherland, G. F. Swain.

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WALTER C. BAILEY, 59 Commercial Street, Lynn, Mass.
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 PHILIP P. PASQUALINO, 151 College Avenue, West Somerville, Mass.

DEATH

GEORGE T. SAMPSON, February 25, 1926.

MEMOIR

GEORGE C. WHIPPLE.*

In the death of GEORGE C. WHIPPLE, on November 27, 1924, the profession lost one of its ablest and most useful members. Mr. Whipple will be remembered not only as an engineer and sanitarian, but as a world-wide educator along lines of public health and sanitary science.

He was born at New Boston, New Hampshire, on March 2, 1866, and went to Chelsea early in his youth, where he received his elementary education, and afterwards was graduated from the Massachusetts Institute of Technology in 1899.

While at the Institute he became interested in fresh water biology and sanitary chemistry, through the influence of Professors Sedgwick and Drown, and upon graduation entered the employ of the Boston water works as biologist of

* Memoir prepared by Allen Hazen and George F. Swain.

the Chestnut Hill laboratory. Here for eight years Mr. Whipple had charge of the sanitary protection of the Boston reservoirs, and organized and equipped the first great water laboratory in America, and did pioneer work in studying micro-organisms in drinking water.

While at Chestnut Hill Mr. Whipple's services were sought in consultation on a number of public water supplies, and his work on the Brooklyn water supply led to his leaving Boston to accept the Directorship of the Mount Prospect laboratory for the city of New York. Here he remained until 1904, having charge of the examination and sanitary control of all the water supplies of greater New York. During this time Mr. Whipple aided in the investigation of different sources of additional water supply for the city, including the Catskill supply, which was soon after authorized and built.

While at the Mount Prospect laboratory Mr. Whipple was increasingly called upon for advice on engineering and sanitary matters in all parts of the country. In 1904 he formed a partnership with Allen Hazen, which continued actively until 1911, and in a limited way until his death.

Mr. Whipple was a born teacher and his services were sought as a lecturer and adviser in outlining courses in chemistry and sanitary engineering. In 1911 he was appointed Gordon McKay Professor of Sanitary Engineering at Harvard University, and during the past twelve years his main interest was in the development of this department at Harvard. Beside this, however, Mr. Whipple found time to take an active part in the Harvard-Technology school of Public Health, first organized in 1913, and afterward continued at Harvard. He also found time to serve the State for ten years as a member of the Public Health Council and Chairman of the Committee on Sanitary Engineering. He was also a member of the Sanitary Commission at Cambridge; of the Zoning Committee of New York City, and a member of the U. S. Public Health reserve.

Mr. Whipple has also done notable service in foreign fields. In 1917 he went to

Russia as a deputy Commissioner of the American Red Cross, and observed conditions in that country during the World War, and particularly the sanitary condition of the troops on the eastern front. In 1920 Mr. Whipple acted for about one year as chief of the Department of Sanitation in the League of Red Cross Societies, with headquarters at Geneva.

Mr. Whipple was a prolific writer. His book on "The Microscopy of Drinking Water" is an authority in this field, and has been rewritten and enlarged through several editions. His work "Typhoid Fever" was an important contribution, both from historical and statistical viewpoints. Among his other works were a review of the work of the Massachusetts State Board of Health, entitled "State Sanitation," and also a treatise entitled "Vital Statistics." He has also written numerous monographs and papers on health matters, — Sanitary Engineering, Microscopy and Fresh Water Biology.

Mr. Whipple was clear-headed and grasped a situation rapidly and accurately. He was best at making a diagnosis of a problem, and was willing that others should do the detail work that followed; but he was capable of continued hard work when it was needed, and would follow a research through its tiresome and laborious processes to a successful termination.

He was one of the most unselfish of men. He was always thinking of the other fellow, and it was a rare case, indeed, where he did not find some common ground of approach and understanding with another man. Every one liked him and there were few men that he could not work with. He was liked by his subordinates because he was fair to them, and gave generous credit for the part they took in his work.

Mr. Whipple was a master of plain, straight English, and could say what was to be said so that all could understand, and he knew how to say what must be said in words that left no sting for those who thought differently.

Mr. Whipple married Mary E. Rayner of Chelsea, Mass., in 1893. Mrs. Whipple, a daughter and son survive him.

RECENT ADDITIONS TO THE LIBRARY

Concrete — Plain and Reinforced. *F. W. Taylor, S. E. Thompson and Edward Smulski*. 4th edition, rewritten. Wiley

Construction of Parallel Wire Cables for Suspension Bridges. *John A. Roebling's Sons Co.**

Drainage and Flood Control. *G. W. Pickels*. McGraw-Hill

Economics of Public Utilities. *L. R. Nash*. McGraw-Hill

Flow of Water in Pipes. *Hiram F. Mills*. *Memoirs of The American Academy of Arts and Sciences*. With historical and personal note by *J. R. Freeman* and introductory outline by *K. R. Kennison*†

Guide. 1925-1926. *American Society of Heating and Ventilating Engineers**

Materials Testing. *I. H. Cowdrey and R. G. Adams*. Wiley*

National Directory of Commodity Specifications. *U. S. Dept. of Commerce*

Practical Accounting for General Contractors. *H. D. Grant*. 2d edition. McGraw-Hill*

Principles and Practice of Surveying, Volume II. *C. B. Breed and G. L. Hosmer*. 3d edition. Wiley*

Superpower. *W. S. Murray*. McGraw-Hill

Water Works Practice — 1925. *American Water Works Association*

now represents the very latest practice in topographic methods. The changes in this edition are as follows:

I. The chapter on Triangulation has been rewritten to conform to recent classification of control for surveys for the Federal government.

II. The chapter on Astronomical Observations has been partly rewritten to conform to the new mode of reckoning Civil Time adopted in 1925.

III. Additions and changes have been made in the chapters on Precise Leveling and Hydrographic Surveying.

IV. A new chapter has been added on the increasingly important subject of Aerial Photographs.

"Construction of Parallel Wire Cables for Suspension Bridges," by John A. Roebling's Sons Company, Trenton, N. J. 1925.

An interesting publication dealing with the fabrication and use of bridge cables for suspension bridges has recently been issued by John A. Roebling's Sons Company of Trenton, N. J.

Beginning with the building of the aqueduct across the Allegheny River at Pittsburgh in 1844, and continuing to the latest completed bridge of suspension type, the Bear Mountain — Hudson River Bridge, this company has either furnished the fabricated cables or supplied the materials for cable fabrication and roadway suspension on many important bridges of this kind in the United States.

This publication includes much data on such subjects as bending stresses in cables due to charge in cable curve, permissible bearing pressure upon wires in saddles, efficiency of strands containing a large number of wires, efficiency of wires around strand shoes, physical properties of No. 6 gauge galvanized bridge wire, coefficient of friction of No. 6 gauge galvanized bridge wire, physical properties of suspender ropes, construction of temporary footbridges, and time study of cable fabrication by the aerial spinning process. Charts are included

BOOK REVIEWS

"The Principles and Practice of Surveying. Volume II. Higher Surveying," by Charles B. Breed, Professor of Railway and Highway, and George L. Hosmer, Professor of Geodesy, Massachusetts Institute of Technology. Third edition, 1926. John Wiley & Sons, Inc., New York. 490 pages.

Volume II, "Higher Surveying," has just been issued in a third edition, and

* Gift of author or publisher.

† Gift of J. R. Freeman and K. R. Kennison. Reviewed in October, 1925, JOURNAL.

giving stress-strain diagrams for various conditions.

An excellent set of photographic studies made during the erection of the Bear Mountain—Hudson River Bridge is given in the latter part of this publication.

In view of the small amount of literature

on the subject of cables for suspension bridges, these data by the Roebling Company are a welcome addition. It is believed that copies of this publication could be obtained upon application to the John A. Roebling's Sons Company, Trenton, N. J.

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